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THE ACTION OF PROTECTING COLLOIDS ON MERCURIC IODIDE.

By Jitsusaburo SAMESHIMA and Takeo SUZUKI.

Received March 3, 1926. Published May 28, 1926.

J. N. Friend[1] described that the mercuric iodide deposited from the mercuric chloride and the potassium iodide solutions in the presence of gelatine is the yellow modification. We have done some experiments on this subject which is described in the following.

When 1 c.c. of 0.1 normal mercuric chloride solution and 1 c.c. of 0.1 normal potassium iodide solution are added to 100 c.c. of 0.0025% gelatine solution, the deposition of mercuric iodide is considerably retarded, but the deposited iodide is ordinary red modification.

When 1.5 c.c. of 0.1 normal mercuric chloride and potassium iodide solutions are added to 100 c.c. of 0.005% gelatine solution, there appears pink coloured turbidity, which, after a while, separates itself into a red precipitate and a white turbid liquid.

When 1.5 c.c. of 0.1 normal mercuric chloride and potassium iodide solutions are added to 0.01% (or more concentrated) gelatine solution, an yellow precipitate appears, which then changes to white. This white substance again changes to the red precipitate after several days.

The yellow precipitate is a modification of mercury iodide which is stable at the temperature higher than 127°. If the pure mercuric chloride and pure potassium iodide solutions are mixed together, the yellow precipitate will appear at first, but it instantaneously changes to the stable red form. If, however, there is a protecting colloid such as gelatine in the solution, then the yellow particles will quickly be enveloped by the colloid, and are prevented to change to the stable modification. The gelatine envelope will prevent the contact of the yellow particles to each other, so the crystal nuclei of red modification can not grow itself, as can be seen in the case of large crystals or a fused mass of mercuric iodide.[2] Moreover, the solubility of the unstable yellow form in water is, of course, greater than that of the stable red form in water, but the rate of solution will considerably be retarded when the particles are wrapped by the gelatine films. So the rate of growing of the stable crystal by the expense of the unstable one will also be retarded.

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(1) J.N. Friend, *Nature*, 109 (1922), 341.

(2) Damiens, *Compt. rend.*, 177 (1923); 178 (1924), 326.

The white precipitate is probably the addition compound of yellow mercuric iodide and gelatine though this is not a stable substance but decomposes into red mercuric iodide and gelatine after a few days.

When 4 c.c. of 0.1 normal mercuric chloride and 4 c.c. of 0.1 normal potassium iodide solutions are added to 100 c.c. of 0.025% gelatine solution, the white liquid has the appearance of the milk. The white substance was separated from the liquid by using a centrifugal machine, and dried and weighed. The dried mass was heated to 400° to decompose the gelatine, and the sublimed mercuric iodide was dissolved into the potassium iodide solution. Then the mercury was estimated by passing hydrogen sulphide in this solution. By this analysis we have seen that the white precipitate was composed of 93% of mercuric iodide and 7% of gelatine, and that 1/4 of the whole gelatine in the solution combined with mercuric iodide.

In the next place, we have examined the protecting action of other colloidal substances than gelatine. The milk, the albumen, the legumine, the extracts of meats, the human saliva, the extracts of vegetables, the solution of wheat flour, etc. have the protecting power on the yellow mercuric iodide. Among these the egg albumen and the extract of the fish have the strongest protecting power, and the mercuric iodide produces not only as the yellow modification but also as an yellow transparent colloidal solution. The agar, the sodium silicate, the starch, the soap, the dextrin, the glycerin, the cane sugar, the urea etc. show no protecting action on yellow mercuric iodide, and precipitate the red form instantaneously.

Generally, we can say that the albuminous substances have the protecting action in this case.

In the following table, the "gold number" of various colloidal substances are compared with their protecting power on the yellow mercuric iodide. The gold number has been determined by the method given by Zsigmondy.[1] The protecting power on mercuric iodide was measured by the quantity of protecting colloid which is necessary to keep the substance in yellow form for 20 minutes, when 5 c.c. of 0.1 normal mercuric chloride and 5 c.c. of 0.1 normal potassium iodide solutions are added to 100 c.c. of water which contains the protecting colloid.

Protecting colloid	Gold number	Protecting power on yellow mercuric iodide
Gelatine	0.009	0.002 gr.
Egg albumen	0.1–0.4	0.01 gr.
Meat extract	1.	0.005 c.c.
Legumine solution	2.	0.1 c.c.
Gum arabic	0.05–0.08	10. gr.
Carrot extract	800.–1000.	50. c.c.

(1) Zsigmondy, "Kolloidchemie," (1922), p. 174.

Protecting colloid	Gold number	Protecting power on yellow mercuric iodide
Agar	0.08–0.1	No action
Sodium oleate	0.8–1.1	No action
Starch	2.	No action
Dextrin	9.–12.	No action
Silicic acid	∞	No action

Thus the protecting action on the colloidal gold and on the yellow mercuric iodide are not quite parallel. The colloids which contain much nitrogen compounds have great protecting power on the yellow mercuric iodide.

A part of the present experiment was done in the chemical laboratory of the Tohoku Imperial University, Sendai.

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ON THE ANOMALOUS DISPERSION AND ABSORPTION OF ELECTRIC WAVES. II.[1]

By San-ichiro MIZUSHIMA.

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As the result of the preliminary experiment it was found that several alcohols, monovalent as well as polyvalent, show anomalous dispersions of the electric wave of 6.1 meters accompanied by anomalous absorptions.[2] Similar experiments were carried out with the wave of 9.5 meters. In this case the values of the dielectric constants were calculated introducing proper corrections to direct observations. Also the values of anomalous absorptions were expressed in terms of electric conductivities which are equivalent to them.

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(1) Read before the Chemical Society of Japan, April 5, 1926.

(2) This journal, 1 (1926), 47.

The oscillating circuit as well as the resonating are quite similar to that used in the case of the wave of 6.1 meters. Fig. 1 shows the resonating circuit.

Measurement of Absorption. If the substance under investigation is non-absorbent, the value I/I_0 (I and I_0 being the deflections of the galvanometer G at the resonance when X is filled with the substance and the air respectively) is always unity, provided that the inductance of the leading wires from C to X is very small. If the substance is an absorbent, I/I_0 is necessarily less than unity, and depends upon the electric capacity of X. To find the expression of the anomalous absorption depending only upon the characteristics of each substance this is replaced by an equivalent normal absorption (*i.e.* an absorption which is caused only by the electric conductivity), and the specific conductivity of the latter is taken as the measure of the former.

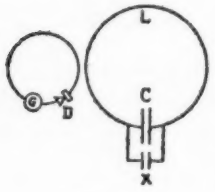

Fig. 1.

A series of experiments showed first of all that water and acetone do not absorb the wave of 9.5 meters and secondly that when the salts such as NaCl, KI, etc. are dissolved in them, the value of I/I_0 depends almost only upon the electric conductivity of the solution. For example the acetone solution of KI and the aqueous solution of NaCl, having the same conductivity, show the same value of I/I_0. These solutions can be used, therefore, as the standards to compare the two kinds of absorptions. The values I/I_0 with respect to corresponding electric conductivities were measured with the acetone solution of KI and the result is shown in Table 1.

TABLE 1.

Approximate Dilution of KI mol per litre	Specific Conductivity $cm^{-1}\ ohm^{-1}$	I/I_0 Vessel I	I/I_0 Vessel II	I/I_0 Vessel III	I/I_0 Vessel IV
240	48×10^{-5}	0.04	0.03	—	—
480	26×10^{-5}	0.08	0.06	0.05	0.04
960	14×10^{-5}	0.16	0.12	0.10	0.09
1920	7×10^{-5}	0.28	0.22	0.19	0.18
3840	3.5×10^{-5}	0.48	0.38	0.35	0.34
7680	1.8×10^{-5}	0.66	0.57	0.55	0.55

Measurement of Dielectric Constant. The value of the dielectric constant ε of a non-absorbent can be obtained from the displacement ΔC of the glass plate of the variable capacity C (Fig. 1). But if the substance is an absorbent, ΔC corresponds to a capacity shunted by a conductivity. Therefore to calculate the value of ε of such a substance from ΔC, the correction which corresponds to this conductivity should be known. In the present experiment the following method was adopted.

Recently Walden[1] studied the change of the dielectric constant between a pure solvent and a solution obtained by dissolving a salt in it, and found that the change is less than a few percent for an organic solvent when the dilution of the salt is as shown in Table 1. The result was confirmed by the experiment on the acetone solution of KI which is described in the following.

A glass vessel which consists of two parts A and B is constructed (Fig. 2). Two platinum wires are sealed in both parts so that the main part of electric capacity lies in A and only a small part in B. The electric capacity is determined in the following three cases; (a) when both A and B are filled with pure acetone, (b) when both A and B are filled with the acetone solution of KI (of a dilution as shown in Table 1.) and (c) when A is filled with pure acetone and B with a solution of such a concentration that the total conductivity is equal to that in the case of (b). The apparent change of capacity caused by the conductivity in the latter two cases should be equal to each other. Therefore the change of the dielectric constant between the solvent and the solution can at once be known if there is any difference of ΔC in these two cases. The result of the experiment shows that no difference can be found within the experimental error which amounts to a few percent, though the value in these two cases is quite different from that in (a). The change of the dielectric constant of acetone can safely be neglected and the correction for the conductivity can be obtained from the difference between ΔC in (a) and that in (b). Table 2 contains the experimental values of ΔC and $\Delta^2 C$ (the difference between ΔC of the solution and that of pure acetone) obtained at the room temperature when the solutions of various conductivities are contained in the vessels I, II, III and IV of X.

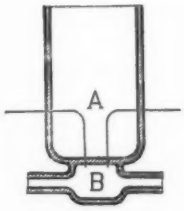

Fig. 2.

(1) Walden, *Z. physik. Chem.*, **115** (1925), 177; **116** (1925), 261.

TABLE 2.

Conductivity cm^{-1} ohm^{-1}	Vessel I		Vessel II		Vessel III		Vessel IV	
	ΔC	$\Delta^2 C$	ΔC	$\Delta^2 C$	ΔC	$\Delta^2 C$	ΔC	$\Delta^2 C$
48×10^{-5}	3.5	0.9	4.6	1.4	—	—	—	—
26×10^{-5}	3.05	0.45	3.7	0.5	4.55	0.7	5.5	0.9
14×10^{-5}	2.75	0.15	3.4	0.2	4.1	0.25	4.9	0.3
7×10^{-5}	2.65	0.05	3.25	0.05	3.9	0.05	4.7	0.1
3.5×10^{-5}	2.6	0	3.2	0	3.85	0	4.6	0
pure acetone	2.6	—	3.2	—	3.85	—	4.6	—

The aqueous solutions of NaCl etc. give the same result as above, *i.e.* the acetone solution of KI and the aqueous solution of NaCl give the same value of $\Delta^2 C$ when the two have the same conductivity and are contained in the same vessel. Hence $\Delta^2 C$ depends merely upon the conductivity of the medium. Thus $\Delta C'$, the corrected value of the displacement ΔC of the glass plate, from which the dielectric constant is to be calculated, can be simply found from the following equation,

$$\Delta C' = \Delta C - \Delta^2 C$$

$\Delta^2 C$ is to be found graphically for each vessel, combining tables 1 and 2, the value I/I_0 being known from a direct observation.

Experimental Results. The wave length was determined with various combinations of inductance and capacity and the result is shown in Table 3.

TABLE 3.

Inductance cm. (E.M.U.)	Capacity cm. (E.S.U.)	Wave length m.
104	22.0	9.50
115	20.0	9.53
127	17.8	9.45

The wave length is, therefore, 9.5 meters.

The experimental data on the non-absorbents, acetone and ether, and the absorbent glycerine are given in the following tables.

I/I_0 : Ratio of the deflections of galvanometer at resonance,
ΔC : Displacement of glass plate,
$\Delta C'$: Corrected value of ΔC,
ε : Dielectric constant,
K : Electric conductivity which is equivalent to anomalous absorption (cm^{-1} ohm^{-1}).

TABLE 4.

Ethyl ether

Vessel	Temp.	I/I_0	ΔC	ε	ε* (Isnardi)
VII	5	1.0	6.25	4.7	4.6
VI	5	1.0	4.3	4.8	4.6
VII	−24	1.0	7.8	5.6	5.5
VI	−24	1.0	5.2	5.6	5.5
VII	−60	1.0	10.0	6.8	6.6
VI	−60	1.0	6.4	6.6	6.6

TABLE 5.

Acetone

Vessel	Temp.	I/I_0	ΔC	ε	ε† (Graffunder)
I	20	1.0	2.55	21	22.4
II	20	1.0	3.2	22	22.4
I	8	1.0	2.8	23	23.9
II	8	1.0	3.55	24	23.9
III	7	1.0	4.05	24	23.9
IV	7	1.0	4.8	24	23.9
III	− 5	1.0	4.3	25	24.5
IV	− 5	1.0	4.8	24	24.5
I	−13	1.0	3.15	25	25.3
II	−13	1.0	3.9	26	25.3
IV	−15	1.0	5.35	26	25.4
III	−15	1.0	4.65	26	25.4
IV	−47	1.0	6.3	29	
III	−47	1.0	5.45	29	
II	−48	1.0	4.75	30	
I	−48	1.0	3.95	30	
III	−51	1.0	5.25	28	
IV	−51	1.0	6.1	28	
III	−66	1.0	5.8	31	
IV	−67	1.0	6.65	30	

* These values of ε are obtained by graphical interpolation. Isnardi, *Phys. Z.*, 22 (1921) 230.

† These values of ε are obtained by graphical interpolation. Graffunder, *Ann. Physik.* 70 (1923), 225.

TABLE 6.

Glycerine

Vessel	Temp.	ΔC	I/I_0	$\Delta C'$	ε	$K \times 10^6$	ε^* (Graffunder)
II	65	5.25	.72	5.25	36	<1	35.2
I	59	4.45	.74	4.45	38	1	36.2
II	50	5.65	.50	5.65	39	2	37.7
I	40	4.9	.48	4.9	41	3	39.4
II	31	6.15	.23	6.15	41	7	40.9
I	25	5.1	.21	5.1	41	10	41.9
II	24	6.4	.14	6.25	42	12	42.0
I	23	5.25	.18	5.2	43	12	42.3
I	22	5.2	.15	5.1	42	15	42.5
I	14	4.95	.09	4.6	37	24	44.0
II	13	5.95	.07	5.5	36	23	44.1
II	12	5.65	.07	5.2	34	23	44.3
I	12	4.55	.09	4.2	34	24	44.3
II	11	5.85	.06	5.3	35	26	44.5
IV	4	6.8	.04	5.9	29	26	46.1
I	3	3.75	.08	3.35	27	26	
I	2	2.75	.08	2.35	19	26	
II	0	3.6	.06	3.05	20	26	
I	− 4	1.95	.09	1.6	14	24	
I	− 9	1.75	.16	1.65	14	14	
II	−11	1.95	.15	1.8	12	11	
IV	−12	2.4	.12	2.2	11	11	
II	−18	1.05	.26	1.05	8	5	
IV	−21	1.4	.29	1.4	8	4	
IV	−24	1.05	.40	1.05	6	3	
II	−30	0.8	.53	0.8	6	2	
II	−33	0.65	.58	0.65	5	2	
IV	−40	0.8	.72	0.8	5	<1	
IV	−41	0.8	.70	0.8	5	1	
II	−51	0.5	.84	0.5	4	<1	
II	−52	0.35	.86	0.35	3	〃	
IV	−58	0.65	.95	0.65	4	〃	
IV	−61	0.5	.98	0.5	3	〃	

* Graffunder, loc. cit.

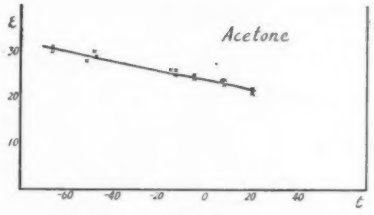

Fig. 3.

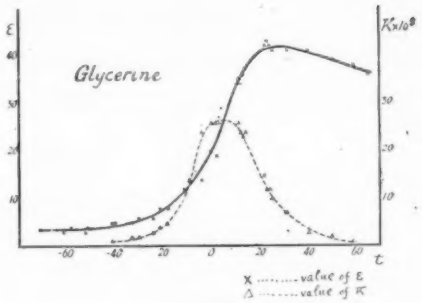

Fig. 4.

Ethyl ether and acetone. (Table 4 and 5, Fig 3). These two substances show no difference between I and I_0 within the limit of the experimental error. The value of ε coincides with that obtained by Isnardi[1] and Graffunder[2] at long wave lengths.

Glycerine. (Table 6, Fig. 4). The anomalous behaviour is quite similar to that at the wave length of 6.1 meters. At low temperatures there is almost no absorption and ε takes a value nearly equal to the square of the refractive indices for the visible light. As the temperature is gradually raised, the absorption of wave takes place, and the value of K increases with ε. K reaches the maximum value at the point where the temperature coefficient of ε is nearly maximum. Then K decreases, but ε still increases till it attains a maximum value. Thence the change of ε is quite normal (i.e. ε decreases as the temperature is raised) and, although there is some absorption in this region, the values of ε obtained are found to coincide with those measured at longer wave lengths.

Further explanation of results will be given in the next paper which will contain the experimental data on monovalent alcohols. The author wishes to express his best thanks to Prof. M. Katayama for his kind guidance.

October, 1925

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(1) Isnardi, loc. cit.
(2) Graffunder, loc. cit.

ETUDES DE DÉRIVÉS DU FURFURAL.

I. CONDENSATION DU FURFURAL AVEC LES CÉTONES ALIPHATIQUES.

Par Itizo KASIWAGI.

Reçu le 27 février 1926. Publié le 28 mai 1926.

L'analogie du furfural avec le benzylal est très remarquable, et des condensations semblables ont lieu, donnant naissance à des produits semblables. On peut classer en plusieurs types les condensations attribuées aux groupements carbonyles que donnent les deux aldéhydes sous l'influence de divers catalyseurs, et nous en mentionnerons ici trois seulement :

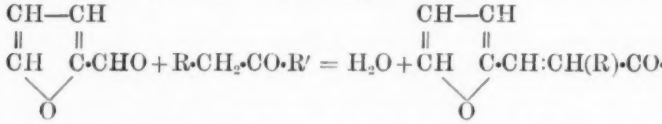
1° Condensation des groupements carbonyles entre eux[1],

2° Condensation des groupements carbonyles et des aldéhydes[2],

3° Condensation des groupements carbonyles et des cétones[3].

Sous l'action des alcalis le furfural se combine avec les cétones toujours de façon que l'oxygène du premier s'élimine à l'état d'eau en se combinant avec les deux atomes d'hydrogène du radical CH, CH_2 ou CH_3 qui est lié au voisinage du groupement fonctionnel CO des deuxièmes. La condensation avec les cétones peut avoir lieu entre les aldéhydes citées ci-dessus et les cétones aliphatiques[3], aromatiques[4], ou cyclaniques[5]. Bien que cette condensation puisse être utile pour constater l'existence du groupe CH_2 voisin du carbonyle dans les molécules[6], la réaction entre le furfural et les cétones — surtout cétones aliphatiques — a été peu étudiée.

Conséquemment nous avons étudié la condensation du furfural avec divers termes de la série des cétones grasses, dont la réaction en présence des alcalis caustiques peut être exprimée par l'équation ci-dessous :



Cette réaction, c'est-à-dire la formation des cétones furyliques non saturées est

(1) Par exemple, la formation de la furoine, la réaction de Cannizzaro, c'est-à-dire la formation de l'alcool et de l'acide sous l'alcali caustique, ou sous l'amidure de sodium (Kasiwagi, Ce journal, 1 (1926), 66) etc.

(2) D. Ivanoff, *Bull. soc. chim.*, (4), 35 (1924), 1658.

(3) Schmidt, *Ber.*, 14 (1881), 1459.
Claisen, *Ber.*, 14 (1881), 2469.

(4) Kostanecki et Podrajansky, *Ber.*, 29 (1896), 2249.

(5) Mlle. N. Wolf, *Ann. chim.*, (9), 20 (1923), 83.

(6) H. Meyer, "Analyse u. Konstitutionsermittlung," 3ème édition (1916), 706.

probablement précédée de la formation des cétols correspondants, qui, par perte d'eau, donnent des cétones non saturées. Les cétols ne sont que les produits d'addition de l'aldéhyde avec les cétones, dont les réactions dépendent, sous l'influence des alcalis, de la tendance migratrice de l'atome d'hydrogène lié à l'atome de carbone au voisinage du groupe CO. Cet atome d'hydrogène se fixe ainsi sur l'atome d'oxygène de l'aldéhyde.

Par conséquent, il est évident qu'une cétone ne possedant qu'à un faible degré cette tendance migratrice ne réagit que difficilement sur l'aldéhyde ou à la faveus d'un agent énergique. Le camphre ne se combine pas avec l'aldéhyde sous l'action des alcalis caustiques, ou de l'alcoolate de sodium,[1] mais il condense avec elle seulement au moyen de l'amidure de sodium.[2]

Partie expérimentale.

La condensation du furfural avec l'acétone sous l'action des alcalis caustiques, fut déjà étudiée par Schmidt[3] et par Claisen[4] et elle est exprimée par la formule :

$$C_4H_3O{\cdot}CHO + CH_3{\cdot}CO{\cdot}CH_3 = H_2O + C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}CH_3 \qquad (I)$$

Cependant, au fur et à mésure de la quantité croissante de furfural, la furyl-1-butén-1-one-3 formée (I) réagit encore avec l'aldéhyde pour donner

$$C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}CH_3 + C_4H_3O{\cdot}CHO$$
$$= H_2O + C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}CH{:}CH{\cdot}C_4H_3O \qquad (II)$$

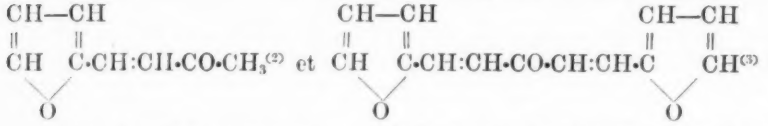
Cette dernière réaction se produit plus ou moins accessoirement avec la réaction (I), et dans des proportions variables, trois molécules d'acétone et une de furfural donnent principalement le dérivé mono-furylique (I), tandis qu'une molécule d'acétone pour deux de furfural donne surtout le dérivé difurylique (II). Ce fait s'est avéré général pour les cétones étudiées.

Voici le mode opératoire : on met dans un flacon convenable 1/10 molécule-gramme de furfural (9,6 gr.), 3/10 molécules-grammes de cétone grasse et de l'eau (250—500 c.c.).[5] On agite ce mélange jusqu'à dissolution complète. Puis on ajoute 10 gr. de soude caustique à 10 pour 100.[6] Cette solution est ensuite agitée à la machine à secouer pendant 6–7 heures. Après plusieurs minutes on voit qu'elle se trouble, et se teinte légèrement en jaune.

(1) Voir Partie expérimentale.
(2) Mlle. N. Wolf, loc. cit.
(3) Schmidt, *Ber.*, **14** (1881), 1459.
(4) Claisen, *Ber.*, **14** (1881), 2469.
(5) On dose la quantité de l'eau selon la solubilité des cétones, et lorqu'elle est très petite, on ajoute de l'alcool.
(6) Pour éviter la polymérisation du produit de réaction on met souvent de la glace pilée dans le mélange (Ivanoff, loc. cit.), mais dans notre expérience le rendement ne s'est pas amélioré par cette addition.

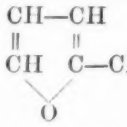
Au bout de la réaction, après avoir ou sans avoir neutralisé la soude en excès, on extrait le corps à l'éther[1], on le lave, et puis on le rectifie sous pression réduite.

1. **Furyl-1-butén-1-one-3** et **Difuryl-1.5-penta-dién-1.4-one-3,**



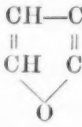
Quand, en les préparant, on varie la proportion de furfural et de cétones, on obtient les rendements aux rapports differants des produit mono- et di-furyliques. On voit au bout de la réaction, que le produit de condensation de deux molécules de furfural et une de cétone, devient bloc dur, duquel on obtient le dérivé di-furylique (rendement, 96 pour 100).

2. **Furyl-1-butanone-3,**



Ce corps est déjà connu,[4] et on peut le préparer facilement, en réduisant la buténone correspondante au moyan de l'amalgame de sodium. Nous avons fait quelques mesures : $d_4^{26}=1.026$[5], $n_D^{25}=1.470$. Réfraction moléculaire : Trouvée, 37.6. Calculée, 37.7.

3. **Furyl-1-penten-1-one-3,**



Par la méthode donnée ci-dessus on a obtenu cette cétone non saturée de l'aldéhyde et de la butanone avec rendement 93 pour 100 de théorie. Une huile jaune claire, très réfringente, et bouillant à 90–95° sous 2 mm., à 126° sous 15 mm., et à 234–235° sous pression ordinaire. Elle ne tarde pas à se teindre en rouge brunâtre même à l'abri de la lumière.

(1) Avant l'extraction, on le distille par une trainée de vapeur d'eau (Schmidt, loc. cit.), mais cette opération est superflue.

(2) Schmidt, loc. cit.; Claisen, loc. cit.

(3) Claisen et Ponder, *Ann. Chem.*, **223** (1884) 146.

(4) Harries et Kaiser, *Ber.*, **32** (1899), 1320.

(5) Harries et Kaiser, $d_4^{19}=1.0361$ (loc. cit.)

(6) La constitution isomérique $C_4H_3O.CH:C(CH_3).CO.CH_3$ est possible. Avec le benzylal et la butanone Harries et Müller ont préparé, sous l'action de l'alcali caustique, un composé de la formule $C_6H_5.CH:CH.CO.CH_2.CH_3$ et, au contraire, sous l'action du chlorure d'hydrogène, une substance isomérique $C_6H_5.CH:C(CH_3).CO.CH_3$ (*Ber.*, **35** (1902), 967. Ici nous admettons *provisoirement* la constitution donnée.

Analyse : Trouvé, C = 72.05, H = 6.36. Calc. pour $C_9H_{10}O_2$, C = 72.00, H = 6.67 %. $d_4^{25} = 1.068$, $n_D^{25} = 1.627$. Réfraction moléculaire : Trouvée, 49.8. Calc., 41.8.

Sémicarbazone :— F = 201.5–202.5° (pas corrigé). Une poudre cristalline, légèrement jaune, de l'alcool.

Analyse : Trouvé, N = 20.8. Calc., pour $C_{10}H_{13}O_2N_3$. N = 20.3 %.

Le dérivé *bisulfitique* ne se forme pas.

4. **Furyl-1-pentanone-3**, $CH{=}CH$ / $CH\ \ C{-}CH_2{\cdot}CH_2{\cdot}CO{\cdot}CH_2{\cdot}CH_3$ / O.

Ce corps, obtenu par réduction de furyl-penténone par l'amalgame de sodium, est une huile assez légère, incolore, bouillant à 206–208° sous pression ordinaire, et à 88° sous 10 mm. Il possède une odeur très agréable.

Analyse : Trouvé, C = 70.8, H = 8.2. Calc. pour $C_9H_{12}O_2$, C = 71.1, H = 7.8 %. $d_4^{25} = 1.003$, $n_D^{25} = 1.468$. Réfraction moléculaire : Trouvée, 42.2 Calc., 42.3.

Ce corps ne se forme pas ni le combinaison *bisulfitique* ni la *sémicarbazone*.

5. **Furyl-1-méthyl-2-pentén-1-one-3**, $CH{=}CH$ / $CH\ \ C{-}CH{:}C(CH_3){\cdot}CO{\cdot}CH_2{\cdot}CH_3$ / O.

On peut préparer la cétone comme précédemment avec un bon rendement de l'aldéhyde et de la pentanone-3. C'est une huile légèrement jaune, bouillant à 135° sous 12 mm., et se colorant comme les homologues inférieurs.

Analyse : Trouvé, C = 73.0, H = 7.7. Calc. pour $C_{10}H_{12}O_2$, C = 73.2, H = 7.3 %. $d_4^{25} = 1.052$. $n_D^{25} = 1.557$. Réfraction moléculaire : Trouvée, 50.5 Calc., 46.4

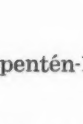
Sémicarbazone, poudre blanche, fusible à 175–176°.

6. **Furyl-1-méthyl-2-pentanone-3**, $CH{=}CH$ / $CH\ \ C{-}CH_2{\cdot}CH(CH_3){\cdot}CO{\cdot}CH_2{\cdot}CH_3$ / O.

La réduction a été faite comme d'habitude, donnant naissance à cette cétone, huile incolore à odeur fruitée et bouillant à 93–100° sous 13 mm.

Analyse : Trouvé, C = 71.6, H = 8.8. Calc. pour $C_{10}H_{14}O_2$, C = 72.3, H = 8.4 %. $d_4^{25} = 0.995$, $n_D^{25} = 1.466$. Réfraction moléculaire : Trouvée, 46.2. Calc., 46.9

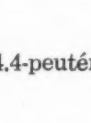
Le dérivé *bisulfitique* ne se forme pas. La *sémicarbazone* n'est pas obtenue à l'état cristallisé.

7. **Furyl-1-methyl-4-pentén-1-one-3,**  $-CH:CH\cdot CO\cdot CH(CH_3)\cdot CH_3$.

Le furfural et la méthyl-3-butanone-2[1] donnent cette cétone, huile légèrement colorée en jaune à odeur rappellant celle de l'orange, et bouillant à 133–136° sous 18 mm. Rendement, environ 60 pour 100.

Analyse : Trouvé, C=73.3, H=7.5. Calc. pour $C_{10}H_{12}O_2$, C=73.2, H=7.3 %. $d_4^{25}=1.0199$, $n_D^{25}=1.557$. Réfraction moléculaire : Trouvée, 51.8. Calc., 46.4.

Il ne se forme pas de dérivé *bisulfitique*.

8. **Furyl-1-dimethyl-4.4-peutén-1-one-3,**  $-CH:CH\cdot CO\cdot C(CH_3)_2\cdot CH_3$.

Cette substance est obtenue avec l'aldéhyde et la diméthyl-2.2-butanone-3 (pinacoline). On a ajouté de l'alcool au mélange initial pour dissoudre complètement les réactifs. Ce corps condensé est une huile jaune à odeur d'orange, et bout à 145–147° sous 35 mm.

Analyse : Trouvé, C=74.1 H=8.0. Calc. pour $C_{11}H_{14}O_2$, C=74.2, H=7.8 %. $d_4^{25}=1.007$, $n_D^{25}=1.548$. Réfraction moléculaire : Trouvée, 56.9 Calc., 51.1.

Cette cétone ne donne ni le dérivé *bisulfitique* ni la *sémicarbazone*.

9. Préparation catalytique de la diméthyl-2.2-butanone-3 (pinacoline)[2]

La transformation du diméthyl-2.3-butane-diol-2.3 en diméthyl-2.2-butanone-3 (pinacone en pinacoline) a été bien étudiée, et en particulier la transformation catalytique en présence de l'alumine par Ipatief[3]. Bien que nous n'ayons pas lu son travail original, il nous semble qu'il a fait passé les vapeurs de diol sur de l'alumine maintenue à 300–320°. Nous avons réussi à préparer cette cétone avec un rendement très satisfaisant, en faisant passer les vapeurs de diol[4] sur une trainée de thorine chauffée à 250°. La thorine est préférable à l'alumine, car elle ne s'encrasse pas si vite, et garde son activité plus long temps. Quand elle a perdu l'activité, on peut la recouvrer par simple calcination.

(1) La méthyl-3-butanone-2 m'a été donnée par mon ami, M. le prof. T. Kusama, que je remercie vivement.

(2) Cette préparation a été faite en collaboration avec M. S. Abe.

(3) P. Sabatier, "La catalyse en chimie organique," 2ème édition (1920), 283.

(4) Ce diol est obtenu par réduction de l'acétone par le magnésium métallique et le chlorure de mercure (Holleman, *Rec. trav. chim.*, 25 (1906), 206. Pour séparer le diol des produits accessoires comme oxyde de mésityle, phorone, etc., on transforme le diol en son hydrate, bien cristallisable, que l'on sépare par essoration de la portion liquide. Par simple distillation du corps hydraté, on obtient le diol à l'état assez pur.

10. Furfural sur camphre.

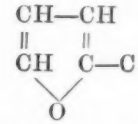
Le dérivé furfurylique correspondant a été obtenu par Mlle. N. Wolf au moyen de l'amidure de sodium. Nous avons repris ce problème et cherché les conditions de la condensation du furfural avec le camphre (1) au moyen de l'alcali caustique, et (2) aussi par l'éthylate de sodium, comme Semmler et Ascher ont fait son étude sur l'essence de carline[1]. Dans l'un et l'autre des essais nous n'avons pas réussi à condenser les deux réactifs.

11. Quelqurs observations sur les écarts des valeurs trouvées et calculées de la réfraction moléculaire.

Réfraction moléculaire des cétones furyliques.

Substance.	Trouvée.	Calculée.	Ecart.
$C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}C_2H_5$	49.8	41.8	8.0
$C_4H_3O{\cdot}CH{:}C(CH_3){\cdot}CO{\cdot}C_2H_5$	50.5	46.4	4.1
$C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}CH(CH_3){\cdot}CH_3$	51.8	46.4	5.4
$C_4H_3O{\cdot}CH{:}CH{\cdot}CO{\cdot}C(CH_3)_2{\cdot}CH_3$	56.9	51.1	5.8
$C_4H_3O{\cdot}CH_2{\cdot}CH_2{\cdot}CO{\cdot}CH_3$	37.6	37.7	–0.1
$C_4H_3O{\cdot}CH_2{\cdot}CH_2{\cdot}CO{\cdot}C_2H_5$	42.2	42.3	–0.1
$C_4H_3O{\cdot}CH_2{\cdot}CH(CH_3){\cdot}CO{\cdot}C_2H_5$	46.2	46.9	–0.7

La table ci-jointe montre que les écarts des valeurs sont remarquables pour les cétones non sarutées, tandis que pour les corps saturés, ils sont presque négligeables. On rencontre ce même phénomène très souvent parmi les dérivés furyliques[2]. Dans la table on voit que tous les composés furyliques qui présentent ces écarts possèdent sans exception un groupement



doubles liaisons conjugées dans les molécules, comme on le voit par ailleurs[3].

Or, par l'étude spectrographique des corps, il nous semble qu'il existe une relation étroite entre l'écartement (l'exaltation) et l'absorption de la lumière, qui sera traitée dans un rapport suivant.

Haute école polytechnique de Yokohama.

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(1) *Ber.*, **42** (1909), 2355. Voir aussi Semmler, *Ber.*, **39** (1906), 726.

(2) D. Ivanoff, loc. cit.; Mlle. N. Wolf, loc. cit.

(3) Le groupement méthyle en position 2 des cétones furyliques produit sur la réfraction moléculaire une diminution de l'écartement. Voir Henrich, "Theorien der organischen Chemie," 5ème édition, (1924), 263.

SYNTHESIS OF METHOXY-HYDROXY-N-METHYL-3·4-DIHYDROISOQUINOLINIUM SALTS.

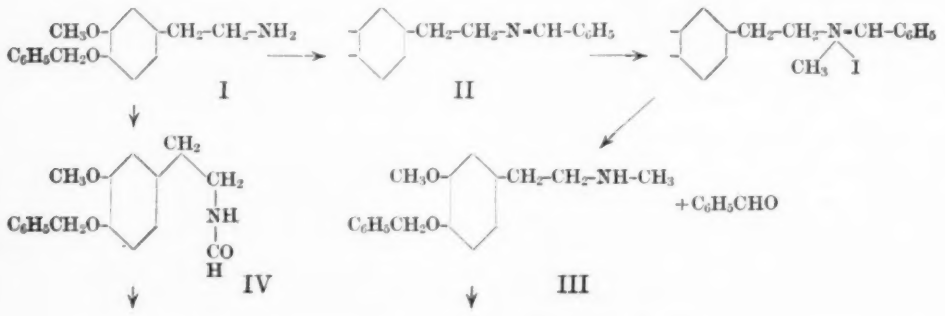
By Shirō AKABORI.

Received April 7, 1926. Published May 28, 1926.

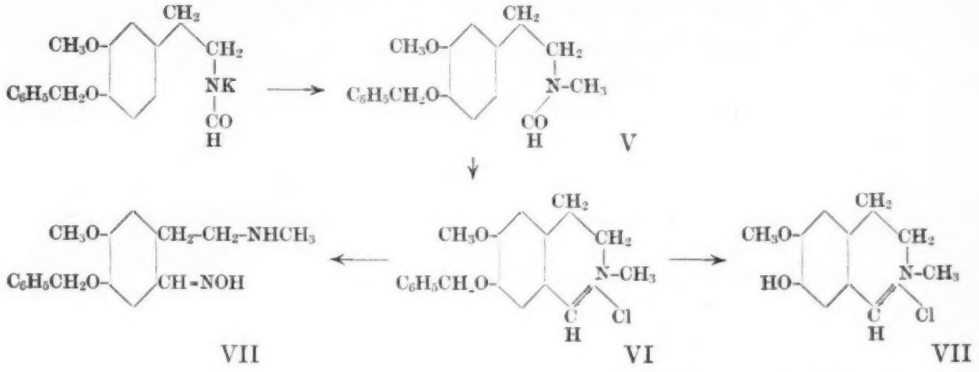
In the dihydroisoquinoline series there are two compounds of much importance from the pharmaceutical point of view. These are hydrastinine and cotarnine, and their hydrochlorides are regarded as having the constitution of 6·7-methylenedioxy-2-methyl-3·4-dihydroisoquinolinium and 6·7-methylenedioxy-8-methoxy-2-methyl-3·4-dihydroisoquinolinium chloride respectively, as is well known. Each of them had first been obtained as an oxidation product of the natural alkaloid hydrastine and of narcotine; later their total synthesis was also successfully achieved.

The present writer has succeeded in preparing several other compounds of this series, namely, 6-methoxy-7-hydroxy-2-methyl-3·4-dihydroisoquinolinium and 6-hydroxy-7-methoxy-2-methyl-3·4-dihydroisoquinolinium salts, as well as their benzylethers. The starting substance is β-(3-methoxy-4-benzyloxyphenyl)-ethylamine (I) which has recently been synthesized by S. Kobayashi.[1]

The method of synthesis which was undertaken and applied successfully in the preparation of 6-methoxy-7-hydroxy-2-methyl-3·4-dihydroisoquinolinium salt (VIII) is expressed by the scheme below.



(1) Kobayashi, *Rikagaku Kenkyujo Iho* (in Japanese), **4** (1925), 527.

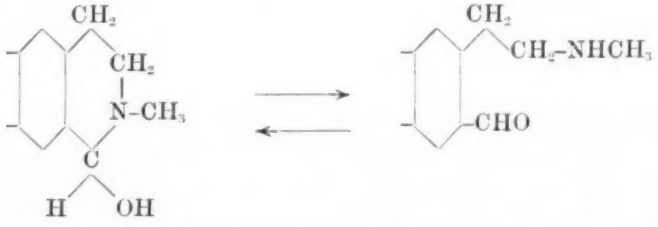


The intra-molecular condensation of formyl-phenyl-ethylamine derivative (V) into dihydroisoquinolinium salt is easily effected by phosphorus oxychloride or thionyl chloride with an exceedingly good yield. Phosphorus pentoxide, however, gives only a poor yield. The most convenient reagent of all is thionyl chloride, for it reacts apparently as follows:—

$$C_{18}H_{21}O_3N + SOCl_2 = C_{18}H_{20}O_2NCl + HCl + SO_2$$

thus directly leading to the formation of the chloride of the expected base. Phosphorus oxychloride, on the other hand, gives the phosphate of the base as an extremely hygroscopic mass, which, therefore, must afterwards be converted into another salt. In spite of the violent evolution of hydrogen chloride at the time of the condensation, the benzyloxyl group remains completely unaffected, while it breaks into benzyl chloride and the free hydroxyl group as a result of the action of concentrated hydrochloric acid.

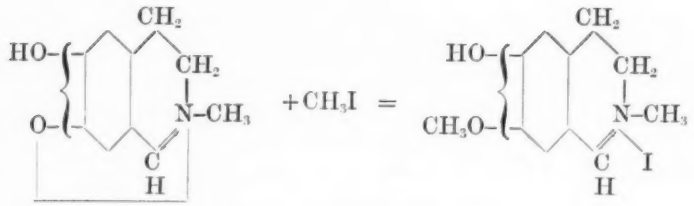
It is well known that the free bases of hydrastinine and cotarnine react with hydroxylamine to give benzaldoxime derivatives, for they exist in tautomeric forms as below.[1]



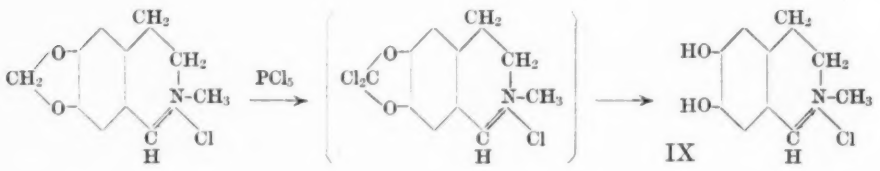
(1) W. Roser, *Ann.*, **249** (1888), 116; **254** (1889), 359.
M. Freund, *Ann.*, **271** (1892), 311; *Ber.*, **22** (1889), 457.
H. Decker, *J. prakt. Chem.*, [2] **47** (1893), 222; *Ber.*, **33** (1900), 2273.
J. Gadamer, *Arch. Pharm.*, **243** (1905), 16.

When treated with hydroxylamine 6-methoxy-7-benzyloxy-2-methyl-3·4-dihydroisoquinolinium salt (VI) is also easily converted into 2-[ω-methylamino-ethyl]-4-methoxy-5-benzyloxy-1-benzaldoxime (VII).

6-Methoxy-7-hydroxy-2-methyl-3·4-dihydroisoquinolinium salt (VIII) is not a new compound, because it has been obtained by F. L. Pyman[1] by the action of methyl iodide on the phenolbetaine of 6·7-dihydroxy-2-methyl-3·4-dihydroisoquinolinium hydroxide (X). But without making any attempt to establish the relative position of the methoxyl and hydroxyl groups, he expressed the reaction as follows:—

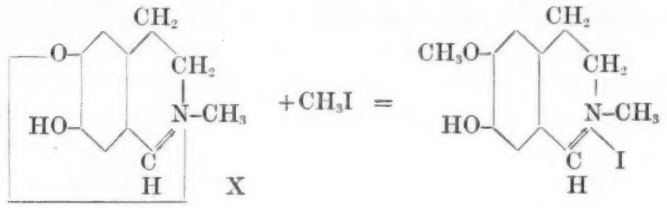


For the purpose of identifying the two substances—Pyman's and the present writer's,—the latter has repeated the former's experiments. 6·7-Dihydroxy-2-methyl-3·4-dihydroisoquinolinium chloride (IX), from which the above mentioned phenolbetaine is readily obtained by treatment with the aqueous solution of sodium carbonate, is prepared by the demethylation of compound VIII, or by the action of phosphorus pentachloride on hydrastinine.



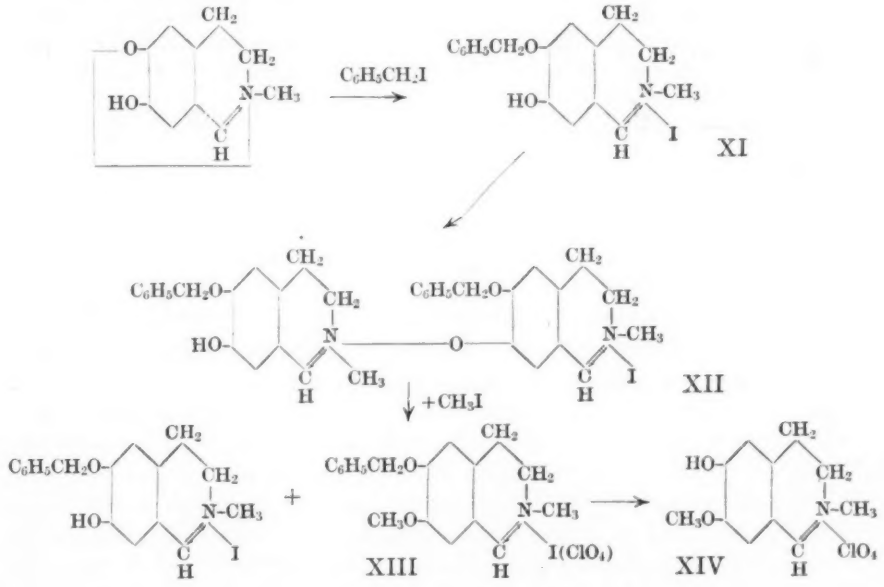
The product of the action of methyl iodide on the phenolbetaine was proved to be absolutely identical with 6-methoxy-7-hydroxy-2-methyl-3·4-dihydroisoquinolinium iodide, having the same decomposition point. The reaction between methyl iodide and the phenolbetaine may, therefore, be more reasonably expressed as follows:—

(1) Pyman, *J. Chem. Soc.*, 97 (1910), 268.



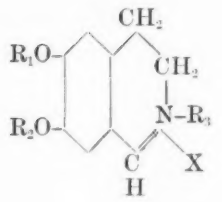
But the present writer has still some doubt about the constitution of the phenolbetaine.

6-Hydroxy-7-methoxy-2-methyl-3·4-dihydroisoquinolinium salt (XIV), which has the hydroxyl and methoxyl groups in alternate positions as compared with compound VIII, was obtained by the following reactions:—



On account of its analogous behaviour, the intermediate compound (XII) is assumed to have a similar constitution to that of Pyman's 6-methoxy-7-[6-methoxy-7-hydroxy-2-methyl-3·4-dihydroisoquinoliniumoxy]-2-methyl-3·4-dihydroisoquinolinium chloride.[1] The method of synthesis adopted by the present writer may be available as a general method for the preparation of any compound of the following general type:—

(1) Pyman, *J. Chem. Soc.*, 97 (1910), 269.



Experimental part.

Methyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine, (III). The synthesis of this new base was carried out according to the method, which H. Decker and P. Becker[1] employed in their synthesis of methyl-homopiperonylamine from homo-piperonylamine. β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine and benzaldehyde, brought together in molecular proportion, react, under spontaneous heating, to give benzal-β-[3-methoxy-4-benzyloxy-phenyl-ethylamine (II). This was purified by recrystallization from a mixture of benzene and petroleum ether; m.p. 57–59°. It crystallizes in light yellow leaflets having a silky lustre.

0.1464 gr. subst. gave 0.4298 gr. CO_2 and 0.0849 gr. H_2O. (Found: C=80.07; H=6.49. $C_{23}H_{23}O_2N$ requires C=79.96; H=6.72%).

The benzal-derivative gives iodemethylate on being heated for about half an hour at 50–60° with methyl iodide in a reflux apparatus perfectly protected from moisture. The iodemethylate is readily hydrolysed in moist alcohol into methyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine hydroiodide and benzaldehyde. The hydrochloride was obtained by passing dry hydrogen chloride into an ethereal solution of the free base. This hydrochloride is easily soluble in water, but moderately so in alcohol, from which it crystallizes in large prisms; m.p. 157–158°. Yield 80%.

0.1303 gr. subst. gave 0.0597 gr. AgCl. 0.1326 gr. subst. gave 0.3213 gr. CO_2 and 0.0844 gr. H_2O. (Found: C=66.08; H=7.12; Cl=11.33. $C_{17}H_{21}O_2N \cdot HCl$ requires C=66.31; H=7.21; Cl=11.53%).

The picrate crystallizes in yellow needles from alcohol; m.p. 163.5–165°. The free base boils under reduced pressure without decomposition; b.p. 200–202° (3.5 mm.)

Methyl-homo-vanillylamine, This amine plays no part in the course of the synthesis, but is somewhat interesting in constitution being closely related to adrenaline. The hydrochloride

(1) Decker u. Becker, *Ann.*, 395 (1913), 336.

was obtained by the action of concentrated hydrochloric acid on methyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine; m.p. 149.5–151°.

0.1011 gr. subst. gave 0.0684 gr. AgCl. 10.08 mg. subst. gave 0.540 c.c. nitrogen (11.5°, 756.5 mm.) (Found: Cl=16.74; N=6.40. $C_{19}H_{15}O_2N$·HCl requires Cl=16.30; N=6.44%).

Formyl-methyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine, (V). 3.2 grams of formate of methyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine (m.p. 105–106°) were heated for half an hour at 170–175°. The product was dissolved in benzene, washed with dilute hydrochloric acid, and subsequently with dilute alkali. After expelling the greater part of the solvent some light petroleum was added. When it had been left standing overnight the formyl-derivative was deposited as a white crystalline mass. This was purified by recrystallization from 50% alcohol, from which it separated in white prismatic crystals; m.p. 78–80°. Yield 2.7 gr. The same compound was also obtained from formyl-β-[3-methoxy-4-benzyloxy-phenyl]-ethylamine (IV m.p. 69–71°) by treatment first with metallic potassium and then with methyl iodide according to D.R.P. 332,474. Yield 90%. This formyl-derivative is readily soluble in ordinary organic media, but insoluble in water.

0.1245 gr. subst. gave 0.3287 gr. CO_2 and 0.0835 gr. H_2O. (Found: C=72.01; H=7.51. $C_{18}H_{21}O_3N$ requires C=72 20; H=6.92%).

6-Methoxy-7-benzyloxy-2-methyl-3·4-dihydroisoquinolinium salts, (VI). 4 grams of the above mentioned compound (V) were dissolved in 20 c.c. of toluene, to which 4 grams of thionyl chloride were added. On being gently heated, the clear mixture became turbid, and then followed a copious evolution of gas, the reaction being complete after a few minutes. The resinous mass, which was deposited at the bottom of the vessel, was separated from the supernatant liquid and washed with light petroleum (during this operation the resinous mass gradually became crystalline), and finally recrystallised from a mixture of alcohol and acetone. This chloride crystallizes in two forms,—one light yellow, short prisms, which melt at 135–138°, after sintering at 125°, the other colourless, large prisms, which melt gradually between 70° and 120°. After being dried in a vacuum at 80°, both of them melt at 135–138° and effervesce at 142°. The aqueous solution of this compound exhibits, in a marked degree, the property of fluorescence, and has a strong bitter taste. These properties are exactly similar to those of hydrastinine. Moreover, in a single qualitative test of its physiological behaviour, it contracted the uterus muscle of a rat.

Yellow sample—0.1078 gr. subst. became 0.1023 gr. after being dried in a vacuum at 80°, and gave 0.0443 gr. AgCl. (Found: H_2O=5.10; Cl=10.17. $C_{18}H_{20}O_2NCl·H_2O$ requires H_2O=5.37; Cl=10.54%).

Colourless sample—0.1644 gr. subst. became 0.1477 gr. after being dried in a vacuum at 80°. (Found: $H_2O=10.16$. $C_{18}H_{21}O_2NCl\cdot 2H_2O$ requires $H_2O=10.19\%$).

Anhydrous sample—0.1082 gr. subst. gave 0.2704 gr. CO_2 and 0.0592 gr. H_2O. (Found: $C=68.16$; $H=6.12$. $C_{18}H_{21}O_2NCl$ requires $C=68.01$; $H=6.35\%$).

The picrate crystallizes in golden-yellow plates, which melt at 177–178°.

5.56 mg. subst. gave 0.505 c.c. nitrogen (9.2°, 762.5 mm.) (Found: $N=11.05$. $C_{24}H_{22}O_9N_4$ requires $N=10.98\%$).

2-(ω-methylamino-ethyl)-4-methoxy-5-benzyloxy-1-benzaldoxime, (VII). 1 gram of 6-methoxy-7-benzyloxy-2-methyl-3·4-dihydroisoquinolinium chloride was dissolved in 10 c.c. of water, to which was added 0.3 gram of hydroxylamine hydrochloride in 5 c.c. of water, and the solution was then made alkaline with sodium carbonate. The whole was slightly warmed on a water bath, when the white crystalline oxime was deposited almost quantitatively. A pure sample, recrystallized from alcohol, melts at 166–167°. It turns red on exposure to the daylight.

0.1081 gr. subst. gave 0.2713 gr. CO_2 and 0.0647 gr. H_2O. (Found: $C=68.46$; $H=6.70$. $C_{18}H_{22}O_3N_2$ requires $C=68.78$; $H=7.06\%$).

(To be continued.)

STUDIES ON PROTEINS. II.[1]

ACTION OF SUPERHEATED WATER ON PROTEINS. I.

By **Shigeru KOMATSU** and **Chuichi OKINAKA.**

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Taylor[2] has observed that when pure sterile globulin from bovine serum was kept in distilled water at ordinary temperature for 18 months, it was hydrolysed to proteoses and partly polymerised into an insoluble form, and also that leucine may be recovered from a sterile suspension of casein in pure water after the lapse of a year or more. These facts indicate that the hydrolysis of proteins in neutral aqueous solution does occur at ordinary temperature, though the velocity of the autohydrolysis of proteins was very slow under these conditions. The influence of heat upon the autohydrolysis of proteins is of considerable interest, since it was a generally accepted view

(1) The first report has been published in *The Journal of Biochemistry*, **2** (1922), 365.

(2) *J. Biol. Chem.*, **1** (1906), 345; "On Fermentation," (1907), p. 223.

that the reaction of hydrolysis is accompanied by the evolution of heat and that the heat-coagulation of proteins was considered to consist in the polymerisation of the amphoteric proteins molecule with the elimination of water according to the following equation:

$$H\cdot X\cdot OH + H\cdot X\cdot OH = H\cdot X\cdot X\cdot OH + H_2O$$

and accordingly, the effect of applying heat to a protein solution must be to shift the equilibrium in the direction of polymerisation, as would follow from van't Hoff's law[1].

The study of the action of superheated water on proteins was first tried by Wöhler[2], and his report was followed by contributions from Subanin[3], Lubavin[4] and others[5] on the isolation of cleavage products of proteins.

The net result of these researches was (1) to establish that the protein body suffers fairly complete hydrolysis at the temperature of steam, and that the equilibrium between the protein-complex and the amino acids, which were regarded as the products of its hydrolysis, was shifted to the amino acids side; (2) to show the presence of leucine, tyrosine, aspartic acid and atmidbodies of complex nature in the reaction products of the proteins.

The extensive researches by R. Neumeister[6], and R.H. Chittenden and F.S. Meara[7] have given us much additional informations concerning the mode of cleavage of the protein molecule, though there are different opinions regarding the nature of the process which have revealed an important connection with the hydrolytic process brought about by the digestive enzymes and also by dilute acids. Many investigators mentioned above, have contented merely to examine the products, especially from the view point of physiology, to find some analogies between the action of superheated water and gastric or pancreatic digestion. Such a too close adherance to

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(1) Robertson, "The Protein," (1909), pp. 141 and 173.
(2) *Lieb. Ann.*, **41** (1842), 238.
(3) Hoppe-Seyler, "Medicin-chem. Untersuch.", (1871), p. 480.
(4) *Ber.*, **10** (1877), 2237.
(5) Hammersten, *Z. physiol Chem.*, **7** (1883), 227.
Krukenberg, *Sitzungsber. der Jenaischen Gesell. für Medicin, etc.* (1886).
A. Clermont, *Compt. rend.*, **105** (1887), 222.
Crismer, *Jahres Berichte f. Thiechemie für 1891*, 19.
Koukol-Yasnopolsky, *Pflüg. Arch. Physiol.*, 12, 85.
R. Neumeister, *Z. Biol.*, **26** (1890), 57; **36** (1898), 420.
E. Salkowski, *Z. Biol.*, **34** (1896), 190; **37** (1899), 404.
R.H. Chittenden and F.S. Meara, *J. physiol.*, **15** (1896), 501.
Blum u. Vaubel, *J. prakt. Chem.*, **56** (1897), 396; **57** (1898), 365.
R. Bauer, *Z. physiol. Chem.*, **35** (1902), 342.
H.S. Steudel, *Z. physiol. Chem.*, **35** (1902), 540.
(6) Loc. cit.
(7) Loc. cit.

analogies might lead investigators into serious error as was already pointed out by Chittenden and Meara, and cause them to fail to pay attention to the unraveling of the constitution of proteins. Furthermore, it was doubtful whether the atmid-bodies would result in a definite chemical composition, in spite of the intensity and duration of heating by which they were produced.

Nobody paid any attention to the formation of the insoluble substance from proteins by the action of superheated water, nor offered any explanation of its relation to the atmid-bodies, all merely dwelling on the constitution of the latter substances. The present research, to heat proteins with water in the iso-electric point, therefore, was undertaken by the authors, to find some chemical relation between the insoluble substance and the atmid-bodies, to propose chemical constitution of protein, if possible, and also to explain the mechanism of the decomposition of protein by superheated water.

The materials employed in the present experiment were three different proteins; edestin, gliadin from wheat flour, and casein from cow's milk, which were prepared by the authors following the directions proposed by T. B. Osborne and his coworkers[1]. The results of the analysis of the samples are shown in the following table:

TABLE 1.

	Edestin	Gliadin	Casein
C.	51.3	53.78	53.39
H.	6.86	6.79	9.10
N.	18.63	17.65	15.55
Ash.	0.7	0.5	0.25
H_2O	6.43	4.1	3.67
Amide-N.	1.88	4.30	1.61
Monoamino-N	10.87	12.25	10.31
Diamino-N.	5.9	1.09	3.49
Melanin-N.	0.12	0.14	0.21
P_H[2]	6.3	5–6 (mean 5.7)	4.6

One gram of protein was introduced with 20 c.c. of distilled water into a glass stoppered bottle of 70 c.c. capacity which was previously washed with steam in order to remove completely any alkaline substance

(1) *J. Am. Chem. Soc.*, **25** (1903), 323.

(2) P_H of the pure protein was determined by the electrometric method of the solution which was prepared by shaking the protein with distilled water in a stoppered bottle for 24 hours. According to Michaelis, the P_H for edestin and for casein is 5.6 and 4.7 respectively, and Eto (*J. Biochem.*, **3** (1924), 373) have given 6.6 for that of gliadin.

which might be generated from the glass wall by the action of steam. The bottle was carefully stoppered, and heated in a thermostat which was kept at the constant temperature of 110° and 120°. The bottle was opened after heating for a certain number of hours, and the fluid which had generally an yellow colour, and gave a neutral reaction to litmus paper, was poured into a flask. The insoluble residue separated from the coloured solution, was washed with cold water, and then dried to constant weight at 105°. The solution and washings combined together, made up to 50 c.c., and the P_H value of the solution was determined electrometrically using one part of the solution. Another part of the solution was evaporated on a water bath to dryness and dried at 110° to constant weight and then analysed.

The elementary composition and the distribution of nitrogen of both the insoluble residue and the solution were determind in the usual way, and the results are shown in Table 2 and Table 3.

The constituents of the hydrolysate of protein by the action of superheated water can be divided, according to their solubilities in water, into two parts; the insoluble residue, and the soluble substances, and the latter composed of a substance of complex nature such as proteose, and of simple amino acids, and the quantity of the soluble substances as was indicated in Table 2, was increased in proportion to the reaction time. The rate of dissolution of protein in water, being different for individual protein, is greatest in edestin, and gliadin and casein were ranged in that order.

The total weight of the hydrolysate as will be seen in Table 2, exceeded in all cases the employed amount of the sample, indicating the hydrolysis of protein molecule occurred in the digestion.

Although the insoluble residue has the same appearance as the mother protein, they are different essentially in composition from each other, as indicated in Table 3, the insoluble residue resulting from edestin is rich in the content of carbon and hydrogen than the mother protein, while that from gliadin is poor in carbon but rich in hydrogen, and the insoluble substance derived from casein is rich in carbon but poor in hydrogen compared with the mother protein.

Generally, the insoluble substance has no definite chemical composition which varying with the external conditions under which the protein was submitted to the chemical action; the substance derived from edestin shows gradual increase in carbon and hydrogen-content with lapse of the reaction time, while that from casein and gliadin keep almost constant value.

These facts led the authors to the conviction that the chemical composi-

tion of the detached groups from protein should vary with each individual protein according to the amino acids of which it was composed[1].

Moreover, the study of the nitrogen distribution of the insoluble and soluble parts by the usual methods, supports the above idea with regard to the composition of the hydrolytic products, and also suggests the formulation of an hypothesis with respect to the nature of the process in which protein undergoes hydrolysis.

When edestin was digested, the groups containing amide nitrogen were removed from the protein molecule mostly at the beginning of the reaction, whilst those containning diamino nitrogen were detached gradually, and consequently the hydrolysis of the protein proceeded in a manner in which the distribution of nitrogen in the residue and solution will approach, in the progress of reaction, that in the original protein. Casein, however, shows quite different behavior toward super heated water, since the atomic groups containing diamino-nitrogen were removed mostly from the protein molecule at the first period of the reaction, and gliadin with respect to its behavior stands between these two proteins.

TABLE, 2.

			Casein (120°)			Gliadin (120°)			Edestin (110°)		
Heating (hrs.)			2	6	17	2	6	15.5	3	6	9
Sample (gr.)			0.8938	0.9740	0.9672	0.9749	0.9880	1.0028	0.9200	0.9200	0.9200
Solution (gr.)			0.012	0.057	0.14	0.054	0.097	0.289	0.134	0.212	0.310
„ (%)			1.34	5.85	14.00	5.5	9.9	28.8	14.3	22.6	33.0
Residue (gr.)			0.9228	0.9331	0.8365	—	0.9414	0.7265	0.8986	0.8678	0.6330
„ (%)			102.6	95.8	86.5	—	96.2	92.4	97.7	94.3	74.2
Distribution of N.	Solution.	Total N. (%)	—	17.0	15.0	16.3	14.4	16.2	16.2	18.7	17.8
		Amide N. (%)	—	4.5	2.6	—	4.6	5.0	3.0	3.4	2.7
		Diam. N. (%)	—	3.3	2.0	—	0.7	0.8	3.7	4.4	4.7
	Residue.	Total N. (%)	16.0	15.3	15.5	—	15.2	23.1	16.9	16.2	18.3
		Amide N. (%)	—	1.3	2.1	—	4.9	6.9	1.6	1.3	1.4
		Diam. N. (%)	—	3.0	5.1	—	0.8	1.5	5.4	4.9	5.3

(1) G. Trier, "Chemie der Pflanzenstoffe," (1924), p. 470.
O. Cohnheim, "Chemie der Eiweisskörper," 3 Aufl. (1911), p. 279.

TABLE, 3.

Elementary Analysis of Residue and P_H of the Solution.									
	Edestin (120°)			Gliadine (120°)			Casein (120°)		
Heating (hrs.)	Carbon	Hydrogen	P_H	Carbon	Hydrogen	P_H	Carbon	Hydrogen	P_H
0	51.36	6.86	6.3	53.87	6.79	5.7	53.39	9.13	4.6
1	51.80	7.55	7.3			—			—
6			—	52.27	7.11	6.8	54.29	7.34	4.7
20	52.46	7.20	6.9	52.19	6.85	6.4	54.27	7.17	5.0

It was a noteworthy fact that the total amide nitrogen of the reaction products at the various stages of the reaction, as will be seen in the case of edestin heated with water at 110°, exceeded that of the protein, and on the contrary there shows a corresponding diminution in the total diamino-nitrogen of the reaction products when compared with the original sample. These facts indicate the transformation of the diamino-nitrogen into amide-nitrogen, and also the phenomenon was noticed markedly in the case of casein, but in gliadin the reaction takes place in the least degree.

Such conversion of nitrogen compounds seems to be more probable when referred to the transformation of glyoxalin by the action of benzoyl chloride and alkali at 0° into bis-benzoyl amino ethylene[1], and also the behavior of tryptophane towards chemicals[2]. Consequently, the process involved in the appearance of the insoluble residue by the action of superheated water on protein was regarded as taking place in at least two ways.

First, there is a formation of an insoluble substance resulting by the removal of the prominent parts from the protein complex. Second, one part of other cleavage products soluble in water, formed simultaneously, was subsequently converted to another insoluble substance by the condensation. The remainder of the soluble substances exists with amino acids side by side in the solution, does or does not change its chemical structure.

(1) Bamberger and Berle, *Lieb. Ann.*, **273** (1893), 351.

(2) Hoppe-Seyler, "Physiol.-Pathol. Chem. Analyse," 9 Aufl. (1924), p. 315.
A. Kossel u. S. Edlbacher, *Z. physiol. Chem.*, **93** (1915), 396.
A. Windaus, *Ber.*, **43** (1910), 499.

The study of the P_H value of the individual reaction products and also their buffer action will be of some important service for the verification of the hypothesis with regard to the chemical reactions above mentioned, and the results will be described in detail in the next article.

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